Glass and Ceramics, Vol. 70, Nos. 7 – 8, November, 2013 (Russian Original, Nos. 7 – 8, July – August, 2013)

EFFECTIVENESS AND QUALITY

UDC 62-51:666.1

EFFECTIVENESS OF CONTROL OF THE FLOAT GLASS PRODUCTION PROCESS

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Translated from *Steklo i Keramika*, No. 7, pp. 11 – 13, July, 2013.

The results of simulation modeling of the control of the float glass production process are presented. It is shown that the systems approach to control is effective, making it possible to solve holistically the problem of economical use of raw materials and energy resources while ensuring high glass quality and limiting adverse environmental impacts.

Key words: sheet glass, technological process, control, production indices.

The main problem in glass production is to produce high-quality glass while limiting any adverse environmental impacts of the production process. Product quality is formed at all stages of the life cycle; the required quality must be maintained at all stages of the production process.

The quality requirements are set by the international standards ISO Ser. 9000. As indicated in the standards ISO Ser. 14,000 attainment of the target environmental indicators can be evaluated by the amount of raw materials used or the energy consumed and the amount of the contaminants NO_x, SO_2, CO, HC, PB and CFC_s produced.

Any improvements to the production process must be continually focused on control and reducing the variability of product characteristics and the parameters of the production process. These problems can be solved by integrated management systems used a glass plants.

In working out corrective actions a decision maker (DM) is guided by the principles of decision making based on analysis of data and information acquired during production. Decision support systems (DSS) are used for real-time data processing. The DM can use the ‘suggestions’ supplied by the DSS or decline them and use a solution based on personal experience in controlling the process. The effectiveness of the corrective actions implemented depends on the likelihood of the ‘suggestions’ being adopted. In this connection there arises the problem of evaluating the effectiveness of the man-machine system as a function of the likelihood of the suggestions generated by the DSS being implemented.

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We shall make use of the concept of repeating the same test under constant conditions [1]. As elementary outcomes of each individual test we shall distinguish two outcomes: the first event is that the DM takes the ‘suggestion’ generated by the DSS and the second is that the DM declines the DSS ‘suggestion’ and adopts a decision based on personal experience in controlling the process. We shall use a binomial distribution with the probability P of the appearance of the first event to model the suggestions adopted by the DM for correcting the controlled process.

We shall now proceed to evaluating the effectiveness of control of the float glass production process at the AGC Borskii Glass Plant, JSC. The operating regimes of the stages of the sheet-glass production lines were picked as the control actions. Since the control actions affect the quality of the glass and the intensity of the environmental impact of the production process simultaneously, this required a systems approach to generating control actions [2].

The problem of controlling the glass production process was formulated in terms of minimizing the losses of energy, raw materials and materials resources and limiting adverse environmental impacts in the production of a planned amount of high-quality glass.

The effectiveness of the control problem formulated and of the criterion chosen was evaluated by means of simulation modeling, which was performed using average daily data obtained during the production of polished glass at AGC Borskii Glass Plant, JSC. The sample used for the modeling was representative. The information collected over a period of one year (365 points) makes it possible to fully reflect all aspects of the functioning of two process lines used in the production of sheet glass, take account of the changes in the

0361-7610/13/0708-0245

TABLE 1. Variation of the Average Float Glass Production Indices, %, versus the Probability of DM Adopting DSS 'Suggestions'

Glass production process index	Manual control parameters, $P = 0$	Variation of indices,* %				
		probability of DM adopting 'suggestions'				with automatic control $P = 1.0$
		$P = 0.2$	$P = 0.4$	$P = 0.6$	$P = 0.8$	
Glass utilization factor, %:						
LPS1	85.28	1.45	3.12	4.39	5.91	7.33
LPS2	86.86	1.54	3.66	4.71	6.78	8.40
Specific gas flow, m^3/kg:						
LPS1	0.218	0.57	0.97	1.04	1.40	1.77
LPS2	0.202	0.13	0.21	–0.01	0.07	0.18
Optical distortions visible in transmitted light, ang. deg:						
LPS1	51.9	–1.03	–1.98	–2.18	–3.61	–4.56
LPS2	61.9	–0.18	–0.52	–0.09	–1.27	–1.47
Optical distortions visible in reflected, mm:						
LPS1	4.29	–10.25	–21.80	–33.16	–46.13	–55.4
LPS2	3.52	0.87	1.08	2.60	3.44	3.9
Carbon oxide concentration in emissions, mg/dm^3:						
LPS1	13.73	–1.52	–1.57	–1.62	–1.81	–1.84
LPS2	2.08	1.67	4.83	5.67	6.57	9.25
Sulfate concentration in process and rain waters, mg/dm^3	31.66	–2.9	–5.59	–7.8	–11.39	–14.12
Illnesses per 100 workers	11	1.24	2.36	2.77	3.2	3.53

* Changes in the float glass production indices, %, compared with manual control.

Note. Minus signs signify a decrease of the index; ang. deg. — angle degree.

composition of the raw materials and ambient environment and other perturbations.

The data obtained from the environmental management system and the professional worker safety and protection systems were monthly values. Interpolation algorithms were used to reconstruct the missing average daily indicators.

The control of the float glass production process comprises a multi-criteria decision making problem. The method of penalty functions was used to solve it [3]. The limits of the range of variation of the regime variables, taken to be the range for manual control of the technological process, were maintained in the simulation modeling.

Simulation modeling was used to evaluate the effectiveness of the functioning of the system with different probabilities for the DM to adopt and implement the DSS 'suggestions' for correcting the technological regimes of the glass production lines LPS1 and LPS2 [4]. The results of the simulation modeling of the float glass production process in the course of one year are presented in Table 1.

Automatic control of the technological process corresponds to the case where the DM adopts and implements all 'suggestions' advanced by the DSS ($P = 1.0$). Control is most effective in this case. The variability in the characteristics of production and in the parameters of the production process decreases. The losses of material and raw materials resources decrease owing to an increase of the glass utilization factor. The specific gas flow changes very little and falls within the limits of the modeling error. The optical distortions of the glass remain within the specifications for M1 glass.

The concentration of harmful substances in the emissions (LPS1) and production wastes decreases. The number of illnesses per 100 workers remains practically unchanged within the modeling error.

The computational experiment showed that as the probability of the DM adopting and implementing DSS 'suggestions' decreases, the effectiveness of the corrective actions taken to control the process also decreases. It should be noted that for probabilities of DM adopted DSS 'suggestions' less than 0.4 the effectiveness of the corrective actions taken by DM decreases significantly.

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